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SIMULATION LABORATORY FOR UNMANNED AERIAL VEHICLE RESEARCH

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Virtual simulations are simulations that are operated at real-world time intervals and usually require human-in-the-loop intervention to accomplish a set of simulation tasks. An example of this type of simulation would be a pair of piloted aircraft working together to acquire and deliver a weapon on to a specific target. For Unmanned Aerial Vehicles (UAVs), this type of simulation will be used to address issues related to mixed fleet operations, autonomous control, concepts of operation, and the UAV operator/vehicle interface.

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Simulation Laboratory for Unmanned Aerial Vehicle Research

The recent successes and ever-increasing roles of Unmanned Aerial Vehicles (UAVs) is forcing the Air Force to better understand how this class of vehicle can operate with and augment today's fleet. (Figure 1 shows an example of such an interaction). In this scenario, both UAVs and manned assets work cooperatively to destroy a series of ground-based threat systems. One way the Air Force can achieve this understanding, as well as explore the necessary interactions and mission effectiveness of these new systems, is through simulation. The Air Vehicles Directorate is developing simulation capability dedicated to UAV research and technology advancement. This capability, located in the Aerospace Vehicle Technology Assessment and Simulation (AVTAS) Laboratory, will use both constructive and virtual simulations (see Simulation Semantics insert) for evaluating UAV technologies and capabilities.

In order for this simulation capability to be useful to engineers and analysts, it must accommodate technology concepts such as sensors, weapons, and control algorithms that vary in fidelity and format. In addition, this capability must enable engineers and analysts to quickly and easily develop and modify mission scenarios in order to evaluate these technology concepts. This entails a development of a "plug and play" simulation environment for evaluating UAV technology concepts.

The idea of a plug and play simulation capability for UAV simulation research involves both hardware and software components. From a software perspective, the fundamental component is the simulation scenario. For this, two mission level modeling tools are being used: the Man-in-the-Loop Air-to-Air System Performance Evaluation Model (MIL-AASPEM) and the Joint Integrated Mission Model (JIMM).

MIL-AASPEM, whose strength lies in the modeling of sensor and weapon systems, will be used to evaluate the role of the UAV as an information, surveillance and reconnaissance (ISR) asset and to understand how UAVs will operate with manned assets in a mixed fleet battle space. In addition, MIL-AASPEM can be used to model ground-based entities and allow for analyzing the ground attack role of the UAV.

JIMM, whose strength lies in the modeling of ground-based systems and their associated tactics, will be used to evaluate the UAV as both a stand alone and mixed fleet attack asset. JIMM enables the user to program tactics and maneuver schemes of ground-based systems to react to the changing events within the scenario. In addition, it enables the modeling of communication schemes and message passing hierarchies-- both critical components for creating an Integrated Air Defense System (IADS) in an air-to-ground scenario.

In addition to the JIMM and MIL-AASPEM software tools, this simulation capability must also allow for software tools that can quickly and easily model a UAV and its subsystems. One such software tool is MATLAB. Through the use of the Simulink and Real-time Workshop packages, MATLAB enables a design engineer to graphically create the functional definition of a UAV and from that design, generate software modules that can be integrated into the simulation

environment. This process enables a seamless transition of a UAV concept from the engineering workstation to the mission level simulation environment.

In order to accurately understand how to optimize a UAV to accomplish a set of mission objectives, it is necessary to be able to dynamically change or re-plan the UAV's objectives as a result of changing events in the scenario. Consequently, another software tool being included in this simulation capability is a Small Business Innovation Research (SBIR) Phase II effort, Large Number of Air Vehicles Simulation (LNAVSIM). LNAVSIM will interface with JIMM and enable a UAV operator to reroute a package of UAV's as a result of unplanned or "pop-up" threats or change UAV mission assignments in response to a destroyed vehicle or change in target priorities. In addition, this software tool will provide a simple mechanism for understanding the role of the operator in UAV operations.

As was previously mentioned, it is also necessary for the hardware components of the simulation capability to be conducive to the plug and play philosophy. Consequently, four Mini-Crew Stations (MCS) (shown in Figure 2), will be used when a manned component is required for UAV technology evaluations. These PC-based cockpits have very simple, programmable cockpit controls, displays and instrumentation. In addition, a PC-based out-the-window visual scene is projected onto a screen located in front of each cockpit. These cockpits can be used for air-to-ground strike, air-to-air attack and in any mix of friendly and foe manned assets.

For the command and control of UAVs, an Operator/Vehicle Interface (OVI) station is also included in the UAV simulation capability. This station (shown in Figure 3) is a traditional up and down configuration that will be used as the communications mechanism between the UAVs, the vehicle operators located at these stations, and the MCS assets. Through this station, the operator will be shown graphical representations of the UAV's functional status and mission objectives. In addition, the operator will use the OVI station as the conduit for passing commands or information to both the UAVs and possibly manned vehicle assets in order to execute the mission objectives. Finally, this station will also be used with LNAVSIM to perform real-time mission route planning for the UAVs.

Through "plug and play" simulation hardware and software, the AVTAS Laboratory is developing a simulation capability that will enable researchers to investigate the best mix of UAV technologies and capabilities required for this class of vehicle to execute a variety of missions. This research can be done either locally or, through the use of the High Level Architecture or Distributive Interactive Simulation protocols, distributed with other simulated or live flight assets to provide an even more realistic and capable evaluation environment. The plug and play design philosophy of this UAV simulation capability as well as its tie to the larger SBR&D process will make it a critical tool for both design engineers and analysts to assess the operational utility of these vehicles.

*Mr. Joe Nalepka and Mr. Matt Duquette of the Air Force Research Laboratory's **Air Vehicles Directorate** wrote this article. For more information contact TECH CONNECT at (800) 203-6451 or place a request at **http://www.afrl.af.mil/techconn/index.htm**. Reference document VA-xx-xx.*

Simulation Semantics

Virtual simulations are simulations that are operated at real-world time intervals and usually require human-in-the-loop intervention to accomplish a set of simulation tasks. An example of this type of simulation would be a pair of piloted aircraft working together to acquire and deliver a weapon on to a specific target. For Unmanned Aerial Vehicles (UAVs), this type of simulation will be used to address issues related to mixed fleet operations, autonomous control, concepts of operation, and the UAV operator/vehicle interface.

In contrast, constructive simulations are simulations that are operated at faster than real-world time intervals and do not require human-in-the-loop intervention to accomplish a set of simulation tasks. An example of this type of simulation, also called a Monte-Carlo Simulation, would be one that analyzes the affect of varying the size of a radar's frequency range of operation over 20 different intervals against 20 different target types. For UAVs, these simulations enable the analyst to execute many experiments in a very short amount of time for the purpose of conducting trade study or stochastic analyses of UAV technologies, configurations, or mission profiles.

In order to explore new technologies and military capabilities, researchers can use both virtual and constructive simulations in a complementary fashion. For example, a set of constructive simulation experiments may be conducted to determine which sensors, out of a set of 20 concepts, are best suited for a particular UAV reconnaissance mission. The purpose of the constructive simulation, in this example, is to eliminate those concepts that are incapable of achieving the objectives and determine which concepts have the potential to meet the objectives but need to be further analyzed in a virtual simulation. The purpose of the virtual simulation is to take this refined list of sensor concepts, incorporate them into an operational environment and examine their effectiveness. The analysis of the virtual results in this setting could focus on determining such issues as: proper implementation of the vehicle and sensor package into the scenario, understanding the data limitations of the sensors, examining the accuracy of the sensors, and understanding how data latencies associated with the sensors can affect execution of the mission profile. To complete the analysis, the results of the virtual simulation are incorporated into the constructive simulation model to not only further improve upon its realism and accuracy but also to provide a better and more accurate representation of a UAV concept. This idea of using one set of simulation results to refine existing simulation models and vehicle concepts is called spiral development and is one of the main techniques of Simulation Based Research and Development (SBR&D).

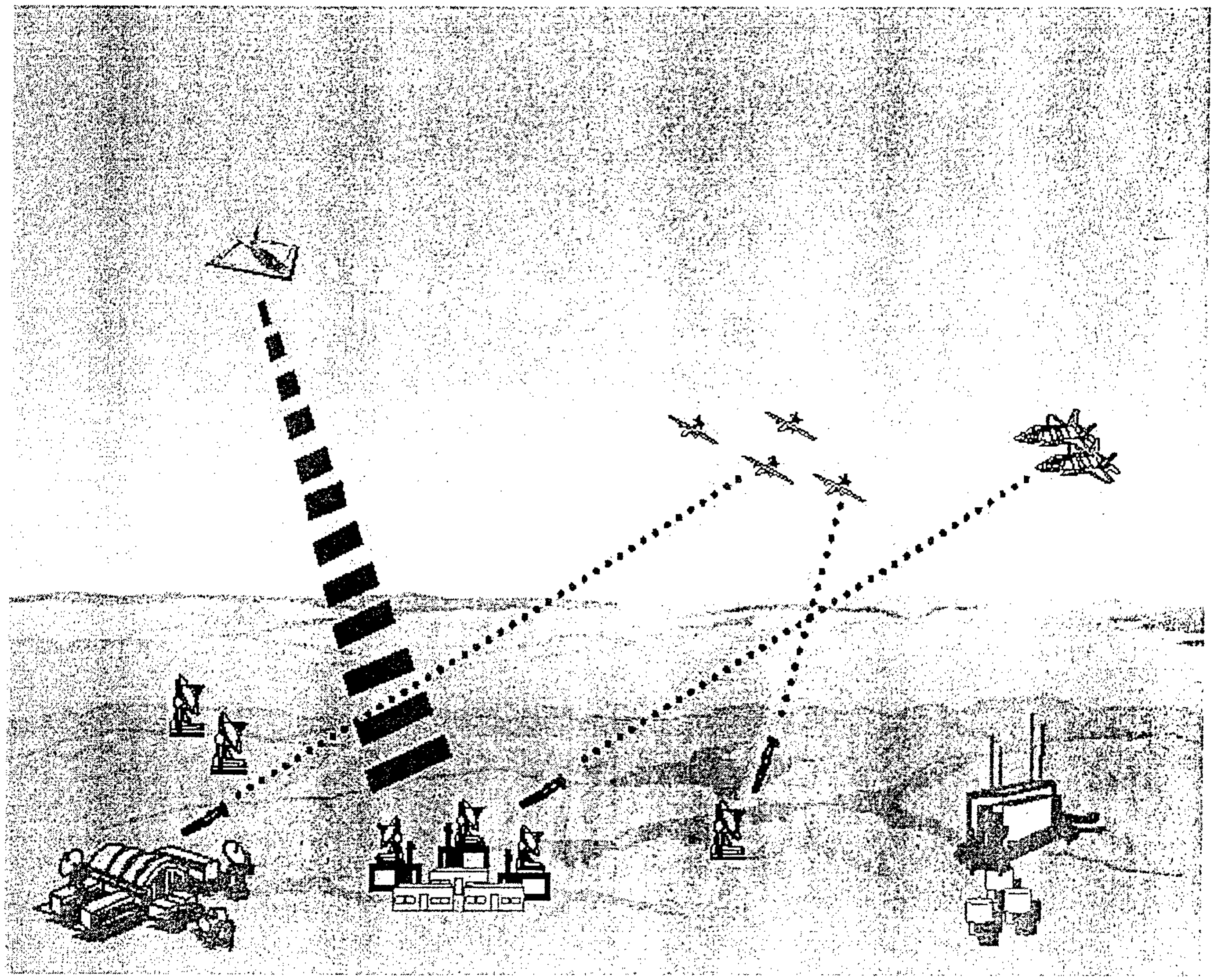

Fig 1

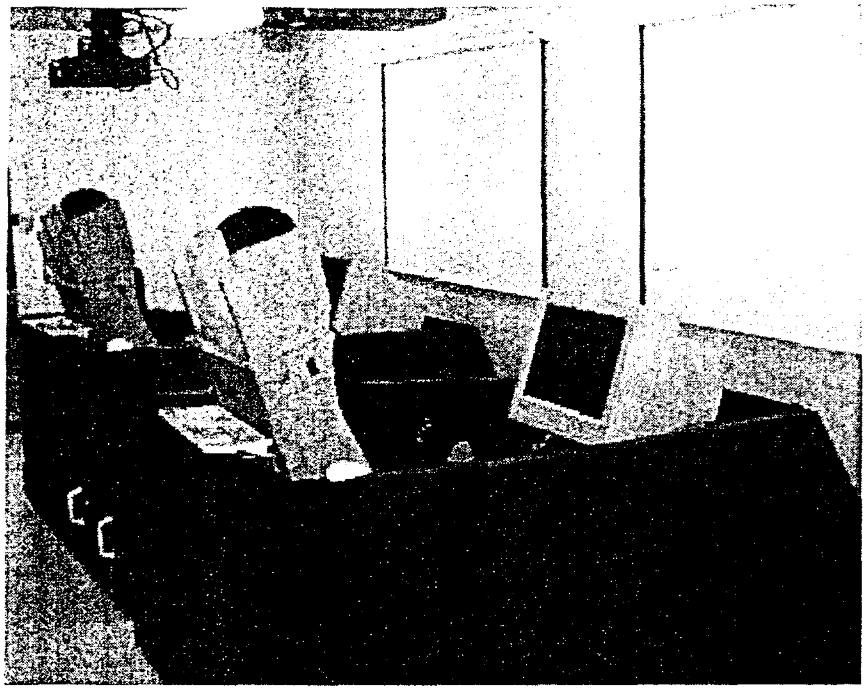

Fig 2

Fig 3